MIKE SHE PP – User Manual

Water Balance Utility

CONTENTS

1 WATER BALANCE UTILITY

The MIKE SHE water balance utility is a post-processing tool, which serve the following purposes:

- A clear unambiguous summary of flow and storage changes for the individual model components as well as for the entire model.

- Analysis of errors occurring in the model due to input data or numerical instabilities.

The water balance utility enables the user to present results for the entire model area or a sub-catchment area (down to single columns).

The MIKE SHE water balance calculation consists of two steps:

1. Execution of the water balance extraction program (mshe_wbl_ex.exe). The extraction program calculates the “gross” water balance for the total catchment or one or more sub-catchments.

2. Execution of the water balance post-processing program (mshe_wbl_post.exe). The post-processing program extracts user defined water balance data.

Figure 1 shows a flow chart for the water balance utility.

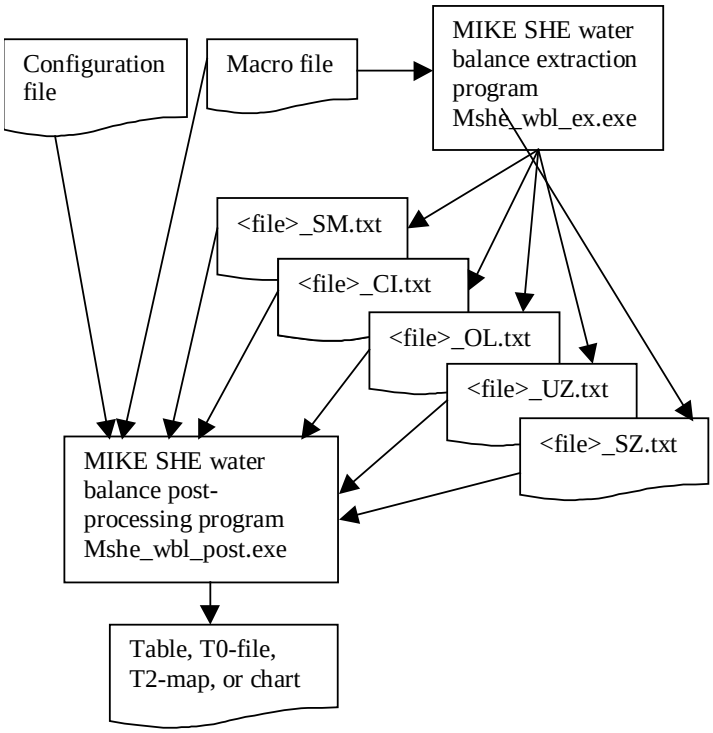

Figure 1 Flow-chart for the water balance utility

1.1 Macro File

The specifications for the extraction and post-processing program are given in a macro file.

1.1.1 Input to MIKE SHE water balance extraction program

Result file	Name of flow result file – extension frf required but no path required.
Wbl-discretisation	Determine the region(s) for which water balance are performed: 1=entire catchment, 2=each sub-catchment, 3=each single cell in the entire catchment, 4=each single cell in areas with sub-catchment grid code=1
Sub-catchment file	Definition of water balance sub-catchments. Only required for wbl-discretisation option 2 and 4. The sub-catchment file (T2-map) should contain zeros in areas where no water balance is wanted and positive number in areas where water balance is wanted. A sub-catchment is defined as a region with same code. The sub-catchment file can contain an arbitrary number

	of sub-catchments. It is recommend that the sub-catchments are numbered from 1 to the number of sub-catchments.
Gross list filename	"base name" for gross list files. Component gross list files are named <filename>_sm.txt, <filename>_ci.txt, etc.

When any of the items in Section 1.1.1 are changed both the MIKE SHE water balance extraction program and the MIKE SHE water balance post-processing program has to be executed.

1.1.2 Input to MIKE SHE water balance post-processing program

Start time	Start date and time for the post-processing of the gross lists
End time	End date and time for the post-processing of the gross lists
Output time step	Time step used in post-processing of the gross lists. The output time step is adjusted to the maximum storing time step if it exceeds the specified output time step.
Output type	1: incremental water balance, 2: accumulated water balance
Water balance type	(SM, CI, OL, UZ, SZ, TOTAL, TOTAL ERROR, etc.) The water balance types are defined in the configuration file
Output format	1: Table, 2: T0-file, 3: T2 map, 4: Table for Chart Program, see Section 1.2
Explode layers	(T/F) water balance showed for all layers when TRUE
Output layer	If the output layer is different from 0 a water balance for the specified layer will be performed
Output location	(ix, iy, isub) Sub-catchment for which water balance is wanted. The sub-catchment is either given as grid coordinates or as a sub-catchment number. If ix and iy equals 0 then isub will be used as sub-catchment. Otherwise the program will determine the sub-catchment form the grid co-ordinates.
Output file name	Name of output file produced by the post-processing program
Default config file	(T/F) when true a default configuration file is used. The file is located as %shedir%\bin\config.wbl, otherwise the configuration file has to be specified

Configuration file	Name of the configuration file for the post-processing program (if Default config file = FALSE), see Section 0

When any of the items in Section 1.1.1 or in Section 1.1.2 are changed the MIKE SHE water balance post-processing program has to be re-executed.

1.1.3 Example of macro file

```
FILETYPE DATATYPE VERNO:   10003          0          501
-------------------------------------------------------------------------------------------------------------------
Setup for MIKE SHE extraction program - run mshe_wbl_ex.exe after editing
-------------------------------------------------------------------------------------------------------------------
Result file          : wie1.frf
Wbl- discritisation : 2
Sub-catchment file : maps\sub-cat.T2
Gross list filename : wbl\gross
-------------------------------------------------------------------------------------------------------------------
Setup for MIKE SHE post processing program - run mshe_wbl_post.exe after editing
-------------------------------------------------------------------------------------------------------------------
Start time           : 1990 6 1 0 0
End time             : 1990 7 12 0 0
Output time step     : 4
Output type          : 1
Water balance type: SZ
Output format        : 1
Explode layers       : F
Output layer         : 0
Output location      : 0 0 3
Output file name     : wbl\szwbl.txt
Default config file  : F
Configuration file   : c:\shedata\config.wbl
```

Several other examples of macro files are given for some of the QC-tests in the %shedir%\data\examples\macro directory. These are referred in Table 2.

Table 1 Examples of macro files for several of the QC-tests.

WBL type	QC1	QC2	QC3	QC4	QC5
SM		QC2_SM.wbl			
CI		QC2_CI.wbl			
OL		QC2_OL.wbl	QC3_OL.wbl		QC5_OL.wbl
UZ		QC2_UZ.wbl			
SZ	QC1_SZ.wbl	QC2_SZ.wbl		QC4_SZ.wbl	QC5_SZ.wbl
ERROR		QC2_ERROR.wbl			
TOTAL	QC1_TOTAL.wbl	QC2_TOTAL.wbl	QC3_TOTAL.wbl	QC4_TOTAL.wbl	QC5_TOTAL.wbl
TOTAL_CHART		QC2_TOTAL_CHART.wbl			QC5_TOTAL_CHART.wbl
TOTAL_ERROR		QC2_TOTAL_ERR.wbl			

1.2 Output Formats

The post-processing program can produce output in four different formats: Table format, T0 format, T2 format and Chart format. All formats except for the T2 format present a water balance for one sub-catchment over a given period of time. The T2 format presents a single water balance group for all sub-catchments.

All results are presented in units of millimetres of water per area. If for an example we look at abstraction presented in a table format with an output time step of 7 days the result will be the accumulated abstraction over 7 days normalised by the area of the observed sub-catchment. Results presented in map or chart format are accumulated over the entire output period specified in the macro file. Results can be converted to m^3 of water by multiplying the result by "the number of cells in the sub-catchment * cell area/1000"

1.2.1 Table format

The table format is a tab-separated ASCII file that can be analysed by any text editor. Table 2 shows an example of the table format.

Table 2 *An example of the table format of the water balance utility. The table shows the accumulated error of layer 1 to 6 for two different time steps distributed with respect to canopy interception (CI), snow melt (SM), overland (OL), river (RIV), unsaturated zone (UZ), saturated zone (SZ), and finally the total error for a selected catchment.*

FILETYPE DATATYPE VERNO: 10006 0 544

ERROR water balance - accumulated - layer 1 to 6 : 1991 1 1 0 0 1994 1 1 0 0

CI OL RIV UZ SZ

Bjerge River Catchment

DHI

CI ERROR	SM ERROR	OL ERROR	RIV ERROR	UZ ERROR		SZ ERROR	TOTAL ERROR
1991 1 26 0 0	.3250502E-03	.0000000	-.1609759E-03	-.1339663	-4.056832	-.4807981E-01	-4.198059
1991 1 26 0 0	.0000000	.0000000	.0000000	.0000000	.0000000	-.7424196E-02	-.1380522E-04
1991 1 26 0 0	.0000000	.0000000	.0000000	.0000000	.0000000	-.1380522E-04	.1757028E-05
1991 1 26 0 0	.0000000	.0000000	.0000000	.0000000	.0000000	.1757028E-05	-.1669177E-04
1991 1 26 0 0	.0000000	.0000000	.0000000	.0000000	.0000000	-.1669177E-04	-.6024096E-05
1991 1 26 0 0	.0000000	.0000000	.0000000	.0000000	.0000000	-.6024096E-05	-.5553877E-01
1991 2 25 0 0	-.6327183E-03	.0000000	.5775230E-03	-.2034599	-6.691113	-.6135943E-01	-6.892560
1991 2 25 0 0	.0000000	.0000000	.0000000	.0000000	.0000000	.2069026E-02	-.9036145E-05
1991 2 25 0 0	.0000000	.0000000	.0000000	.0000000	.0000000	-.9036145E-05	-.1066767E-04
1991 2 25 0 0	.0000000	.0000000	.0000000	.0000000	.0000000	-.1066767E-04	-.1418173E-04
1991 2 25 0 0	.0000000	.0000000	.0000000	.0000000	.0000000	-.1418173E-04	.2761043E-05
1991 2 25 0 0	.0000000	.0000000	.0000000	.0000000	.0000000	.2761043E-05	-.5932153E-01

The format is suitable for viewing and editing in a spread sheet program. The table presents water balances over a given period of time with specified time steps. The water balance can be incremental or accumulated. If SZ is included in the water balance either the

individual layers can be presented as additional rows for each time entry or the water balance can be presented for all layers in one row.

1.2.2 T0 format

The T0 format is at the present stage not implemented.

1.2.3 T2 format

The T2 output option is designed for viewing the distribution of a single water balance group. Specifically, the option is used for analysing the distribution of errors. The distribution of errors is presented in sub-catchments. If the water balance is calculated in all cells (Wbl-discretisation = 3 or 4) it will be possible to present the error (or any other parameter) in all cells. The presented values are accumulated values from start date to end date. An example of the T2 output is given in Figure 2.

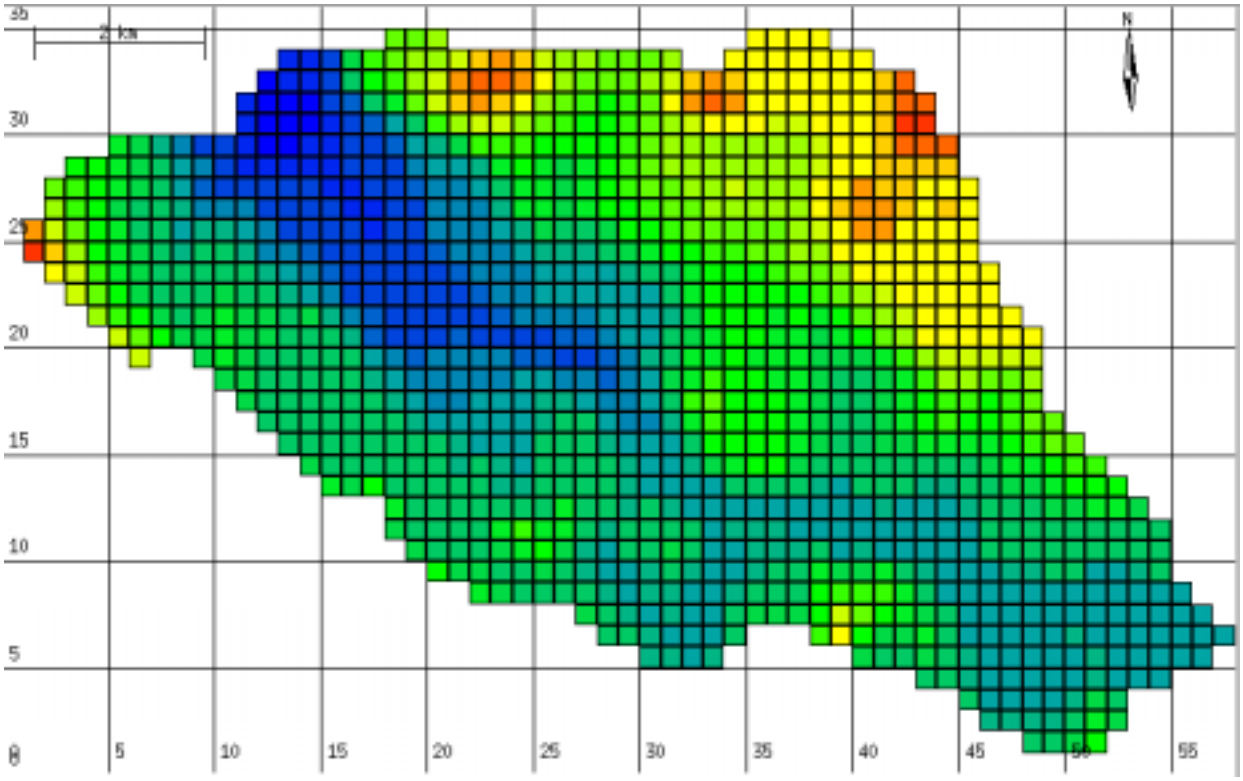

Figure 2 *An example of the T2 output map. The map shows the distribution of the error of the unsaturated zone component. As this error was significantly influencing the total error according to Table 2 a further investigation of the error source can be done by means of the T2 map.*

The T2-files can be edited from the MIKE SHE 2D Graphical Editor, see the MIKE SHE User Guide on Pre- and Post- processing.

1.2.4 Chart format

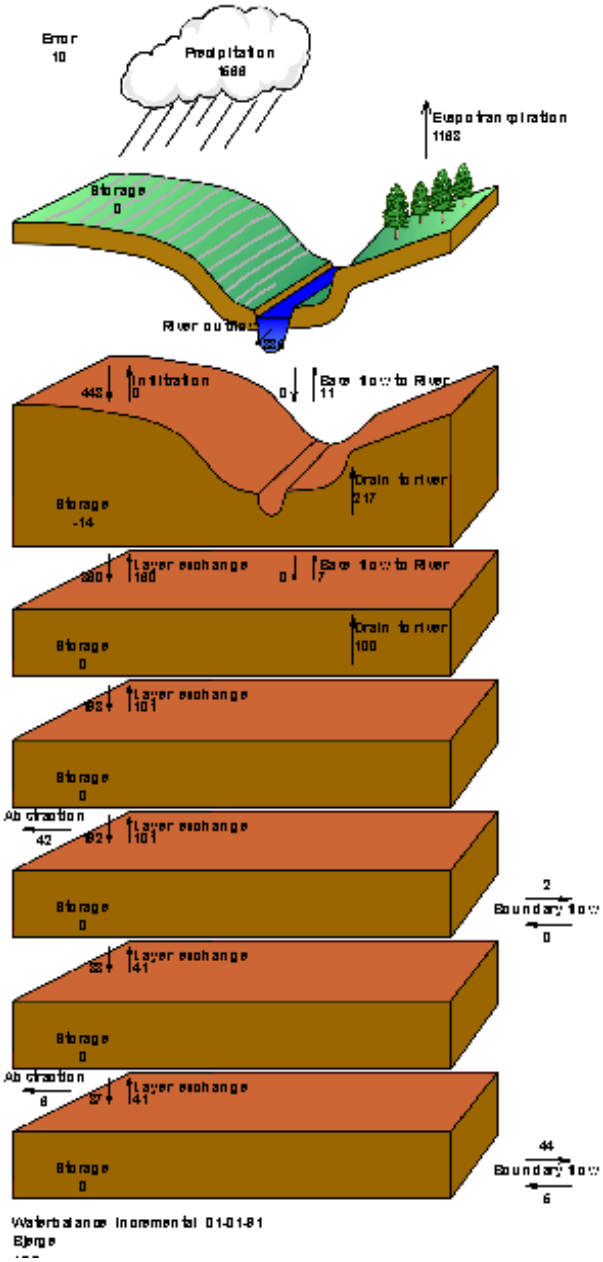

Figure 3 *An example of the water balance chart. The chart shows the accumulated water balance the entire hydrological cycle: of six geological layers, of the ground surface, and of the atmosphere. The unsaturated zone is included in the most upper layer.*

The Chart format is the file format for the water balance Chart Program. As for the T2 format all presented values are accumulated values from start date to end date. The water balance Chart Program only supports a few water balance types, see the config file for further information. An example of the water balance chart is given in Figure 3.

To run the water balance Chart Program, see Section 1.6.2.

1.3 Storage Requirement in the Flow Result File

In order to achieve a correct water balance calculation a number of data types have to be stored in the Flow Result File. Table 3 shows the data types for each component that has to be stored.

Table 3 *Required storage of data types. The user has to include all data types that are highlighted for the components included in the simulation. If e.g. the user wants to include snow melt (SM) in the simulation, it is a requirement to include data types 1 (precipitation) and 21 (snow storage) in the storing of results (menu F.2.a of the MIKE SHE menu system).*

Data type	Component					Data type	Component				
	ET	SM	OC	UZ	SZ		ET	SM	OC	UZ	SZ
1						21					
2						22					
3						23					
4						24					
5						25					
6						26					
7						27					
8						28					
9						29					
10						30					
11						31					
12						32					
13						33					
14						34					
15						35					
16						36					
17						37					
18						38					
19						39					
20						40					

1.4 Configuration File

The configuration file specifies the contents of the defined water balance type. For given water balance types a number of groups are specified. Each group consists of one or more water balance items. Group items are added together (or subtracted) in the presentation. Component specification is required for all items. A predefined set of water balance types is present in the file \she540\bin\config.wbl. A complete overview of all water balance items is listed in Section 1.5. Groups can have arbitrary names, while item names has to be identical to the names listed in Section 1.5.

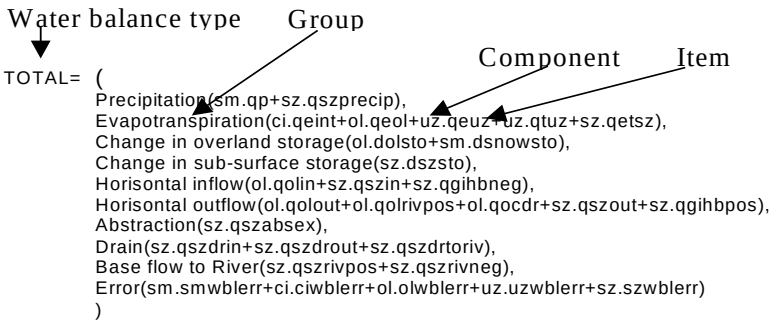

Figure 4 Example of water balance type specification. A group could be "Evapotranspiration", a component could be "ol", and an item could be "qeol".

1.5 Water Balance Items

The water balance extract program (mshe_wbl_ex.exe) calculates component water balance for the snowmelt component, the canopy interception component, the overland component, the unsaturated zone component, and the saturated zone component. Water balance calculations are performed at the maximum storing time step given in the water movement module (WM).

Recall that all units are given in millimetres of water per area.

The water balances for each component are written to so-called gross files. This section lists the water balance terms that are present in the gross files.

Snowmelt Terms (SM)		
Item	***Description***	***Sign***
qp	Precipitation	Positive upwards
qirrsprinklerin	Sprinkler Irrigation from source inside the sub-catchment	Positive out (always negative)
qirrsprinklerex	Sprinkler Irrigation from source outside the sub-catchment	Positive out (always negative)
qpad	Precipitation deducted snow and evaporation	Positive upwards
dsnowsto	Change in snow storage	Positive when increasing
qesnow	Evaporation from snow	Positive out (not implemented!!!!)
smwblerr	SM Water balance error	Positive when the component generates water

Canopy Interception Terms (CI)		
Item	***Description***	***Sign***
qpad	Precipitation deducted snow	Positive upwards
qpnet	Canopy through-fall	Positive upwards
qeint	Evaporation from intercepted water	Positive out
dintsto	Change in interception storage	Positive when increasing
ciwblerr	CI Water balance error	Positive when the component generates water

Overland Terms (OL)		
Item	***Description***	***Sign***
qpnet	Canopy through-fall	
qirrsheetin	Sheet Irrigation from source inside the sub-catchment	Positive out (always negative)
qirrsheetex	Sheet Irrigation from source outside the sub-catchment	Positive out (always negative)
qirrdripin	Drip Irrigation from source inside the sub-catchment	Positive out (always negative)
qirrdripex	Drip Irrigation from source outside the sub-catchment	Positive out (always negative)
qeol	Evaporation from ponded water	
qolin	OL potential flow into sub-catchment	
qolout	OL potential flow out of sub-catchment	
qolrivpos	Overland flow to river	
qocdr	Overland flow directly to river (from paved areas)	
qh	Infiltration from OL to UZ	
qolszpos	Upwards potential flow from SZ to OL	
qolszneg	Downwards potential flow from OL to SZ	
qsztofloodpos	SZ flow to flooded areas	
Qsztofloodneg	flow to SZ from flooded areas	
Qfloodtorivin	Exchange from overland flooded areas to river inside the sub-catchment	
Qfloodtorivex	Exchange from overland flooded areas to river outside the sub-catchment	
Dolsto	Change in overland storage	
Olwblerr	OL water balance error – positive when the component generates water	

Unsaturated Zone Terms (UZ)		
Item	***Description***	***Sign***
Qh	OL – UZ infiltration	
Qrech	UZ - SZ recharge	
Qtuz	Transpiration from root zone	
Qeuz	Evaporation from soil	
Qgwfeedbackuz	Feedback form linear reservoir(LR) to UZ	
Duzdef	Change in UZ deficit	
Uzwblerr	UZ Water balance error	

Saturated Zone Terms (SZ)		
Item	***Description***	***Sign***
Qrech	UZ – SZ recharge	
Qszprecip	Precipitation added directly to SZ	
Qetsz	SZ evapotranspiration	
Qszin	SZ potential flow into sub-catchment	
Qszout	SZ potential flow out of sub-catchment	
Qszzpos	Upwards SZ potential flow from layer i+1 to layer i	
Qszzneg	Downwards SZ potential flow from layer i to layer i+1	
Dszsto	Change in SZ storage	
Szstocorr	UZ-SZ storage adjustment term – difference in unconfined storage capacity for UZ and SZ	
Qolszpos	Upwards potential flow from SZ to OL	
Qolszneg	Downwards potential flow from OL to SZ	
Qszabsex	SZ abstraction	
Qszdrin	SZ drainage into subcatchment	
Qszdrout	SZ drainage out of subcatchment	
Qszdrtoriviin	SZ drainage flow to rivers inside the subcatchment	
Qszdrtorivex	SZ drainage flow to river outside the subcatchment	
Qszrivpos	SZ aquifer inflow to river	
Qszrivneg	River flow to SZ aquifer	
Qgihbpos	Flow to General Internal Head Boundary cell	
Qgihbneg	Flow from General Internal Head Boundary cell	
Qirrshallowwell	Abstraction from shallow well to irrigation - positive out	
Qirrremotewell	Abstraction from remote well to irrigation - positive out	
Szwblerr	SZ water balance for layer i	
Szwblerrtot	SZ water balance for sub-catchment - positive when model generates water	

1.6 Running the Water Balance Utility

The water balance utility consists of two console/DOS applications and a Windows application. There is no graphical user interface for the water balance execution implemented at the present stage. The steps of the execution of the water balance utility are outlined in the next sections.

1.6.1 Calculate the water balance

- Open a dos-prompt.
- Change directory to the MIKE SHE working directory (The one with the Dbase, Digfiles, Macro, etc. directories).
- Edit your macro file . . .
- Execute the extraction program by writing: “mshe_wbl_ex” The program will now prompt for the macro file name. Alternative write echo “<Macro file name> | mshe_wbl_ex” or simply “mshe_wbl_ex < runwbl.txt” where runwbl.txt is a text file containing the path and name of the macro file.
- Execution can be performed by utilising a batch program, see Figure 5.

```
echo Macro\91-93.wbl | mshe_wbl_ex > tmpfile
echo Macro\91-93.wbl | mshe_wbl_post > tmpfile
echo Macro\91.wbl | mshe_wbl_ex > tmpfile
echo Macro\91.wbl | mshe_wbl_post > tmpfile
echo Macro\92.wbl | mshe_wbl_ex > tmpfile
echo Macro\92.wbl | mshe_wbl_post > tmpfile
echo Macro\93.wbl | mshe_wbl_ex > tmpfile
echo Macro\93.wbl | mshe_wbl_post > tmpfile
echo Macro\91-93error.wbl | mshe_wbl_ex > tmpfile
echo Macro\91-93error.wbl | mshe_wbl_post > tmpfile
echo Macro\UZerror.wbl | mshe_wbl_ex > tmpfile
echo Macro\UZerror.wbl | mshe_wbl_post > tmpfile
del tmpfile
```

Figure 5 *An example of DOS commands assembled in a batch program (runwbl.bat) for automatic execution of a series of water balance investigations. In this sequence the water balance is calculated over a 3-year period (1991-1993) and for each of the individual years with chart illustration as purpose. The entire error contribution will be tabulated and the error distribution of the unsaturated zone will be mapped. The tmpfile contains the screen dump and is finally erased.*

- The execution of the post-processing program, mshe_wbl_post.exe, is analogue to the execution of the extraction program.

- Do ALWAYS check the SIGNALS directory for error files produced by the extraction or post-processing program.

1.6.2 Illustrate the water balance in a chart

To run the water balance Chart Program to create a water balance chart:

- Run the "mshe_wbl_ex" and "mshe_wbl_post" programs with output format = 4.

- Run the windows application "WblChart.exe" (\she540\bin\WblChart.exe).
- From the WblChart program: Open the wbl output file to show the chart.
- Notice: A shortcut of the WblChart program can be located on the desktop (target: C:\she540\bin\WblChart.exe, start in: C:\she540\bin). Double click the icon and open the wbl output file or simply "drag and drop" the wbl output file into the icon to show the chart.
- Notice: The chart may appear slightly different on screen compared to on print or print preview.